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SUBJECT: MONTHLY PROGRESS REPORT ON [redacted] JOB 1459 50X1

This report covers work performed on [redacted] Job 1459 during the 50X1
month ending November 15, 1958.

A meeting was held at the Research Department on October 21, 1958, at which progress was reported and anticipated problems discussed. At the time of that meeting, it was felt that the multiplier-integrator approach was more practical in this application than the matched filter approach because it permitted the modulation to be derived from a shift register sequence generator rather than requiring a multi-tapped delay line or other elaborate circuitry in the transmitter. Further study, however, has revealed that the multiplier-integrator approach leads to severe difficulties in attempting to meet other requirements of this system. This has forced a major revision of ideas, the ultimate consequences of which are now far from clear. The critical considerations here are centered on the extent to which message bauds are transmitted synchronously or asynchronously.

Conventional teletype may be either synchronous or asynchronous. Without going into the advantages of each, it is sufficient to note that such a choice is possible only because each signal pulse is individually detectable even though the starting time of a pulse or group of pulses is not precisely known in advance. In the present case, however, the signal by design is presumed to be not detectable without knowledge (whether given a priori or derived by a search operation in the receiver) of a large number of para-







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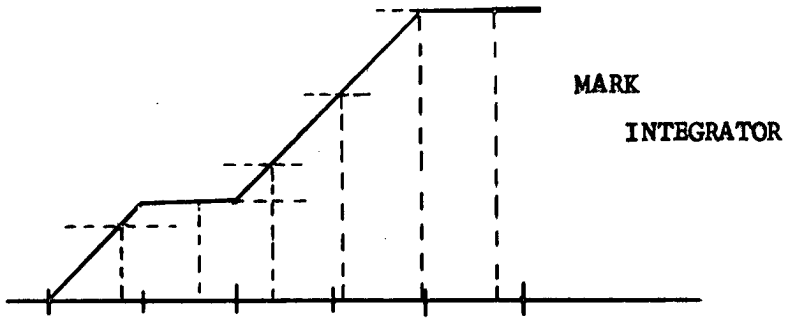
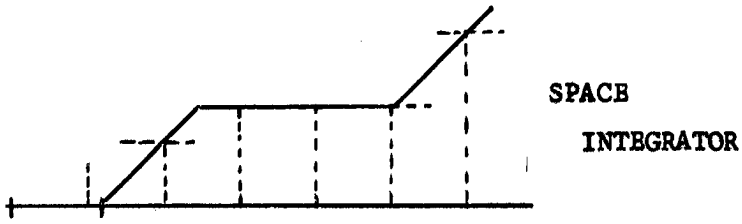
meters of the signal. This is true of both the matched filter and the multiplier-integrator approach, but with the latter approach a further essential parameter is required, namely, signal epoch; i.e., the starting time of each pulse or group of pulses. In precise synchronous operation, the signal epoch is, of course, predictable because of the uniformity of intervening intervals. With asynchronous operation, it is necessary to re-establish the time epoch frequently; e.g., with each letter or at some other appropriate interval. This is not an additional burden on a matched filter receiver since it merely affects the times at which the correlation peaks occur in the output of the receiver. We need merely wait until the output exceeds a certain threshold value. On the other hand, this results in an impossibly severe strain on a multiplier-integrator system, requiring something like a parallel gate system with a family of multiplier-integrators operating in parallel.

The way this difficulty manifests itself in a multiplier-integrator system is that the receiver does not know when to make the mark versus space decision, and when to dump the integrators. The first of these objections is not critical because the decision can be made a little earlier than it otherwise would with only tolerable performance degradation (similar to that suffered in the matched filter system by waiting for a threshold to be exceeded rather than sampling at just the optimum time). The second difficulty, that of not knowing when to dump the integrator, is a critical one. The accompanying sketch indicates the problem involved in trying to resolve a mark-space-mark-mark-space. The two curves are the output of the mark (upper) integrator and the space (lower) integrator if never dumped; dumping amounts




Intended: Mark Space Mark Mark Space

Decided: Mark Space (Either) Mark Mark




to pulling the curves back to a new zero reference which is indicated on the signal by drawing a new reference base line at each dump point. The effect of noise is not shown in these curves; if noise were taken into account, the difficulties would be slightly worse. It is assumed in this sketch that the decision is made and the integrators dumped after a time which is 0.8 of the true baud duration. It is seen that the correct decisions are made for a few bauds but that then the receiver gets badly out of step and the message from this point may be expected to be thoroughly jumbled.

We seem then to be faced with a "devil's choice": synchronous transmission, or matched filters? Several procedures for synchronous transmission will now be considered.

1. It is assumed that the message to be transmitted is initially stored on a magnetic tape or disc, or other compact arrangement. Stability of read-out rates then depends on mechanical motion. This cannot be controlled accurately within the indicated constraints; even the elaborate "wow-free" mechanical tape transport mechanisms of expensive (and large and heavy!) tape recorders would probably be grossly inadequate here.

2. Purely electrical storage and read-out schemes are conceivable, such as a 2500-bit shift register. This is obviously unattractive.

3. Mixed mechanical/electrical schemes of various sorts are conceivable.

(a) Read from tape to intermediate storage in a shift register, permitting synchronous read-out. The read-from-tape, of course must never lag behind the transmission. If it gets too far ahead, the intermediate storage requirement becomes excessive. If it is assumed that the tape speed can only be controlled to within 5% of a predetermined value, then provision must be made for intermediate storage of $0.05 \times 2500 = 125$ bits. This is cumbersome, but perhaps not unthinkable.

(b) Encode instantaneous speed as a binary number to be tacked onto each synchronous group; e.g., if an entire 5-letter word is read into a shift register, and then read out synchronously, a 10-bit binary number may be appended to indicate the current inter-word interval (i.e., where to look for the next word) to within 0.1%. In the receiver, this

is used to generate (perhaps after smoothing) a gate position correction.

Variants of these schemes are possible with more or less intermediate storage, more or less speed control, and more or less transmitted synchronization information. In general, none of these possibilities seem very attractive, but a reasonable scheme ultimately may be found among the numerous possibilities.

The other alternative of the "devil's choice", namely, the matched filter approach, must be reconsidered in view of its important basic property of operating independently of signal epoch. We have recently learned of a proposed* new type of delay line stated to permit a WT product of 800. Details of construction are not immediately available to permit an evaluation of its applicability to the present problem.

To summarize the present status of the work, the synchronization problems are considerably more complex than realized at the time of our last meeting. Considerable concern is now felt as to whether the December 31st date can be met successfully. Funds remaining are entirely adequate to complete the investigation, but it may be necessary to ask for a short extension of time. We will contact the agency immediately as soon as we feel that we have a clear picture in this connection.

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PREPARED BY [redacted]

Associate Director of Research

* M. E. Golay, et al, "A Conjugate Filter Data System Link," Proceedings of the RADC ECCM Symposium, Volume II, October 22,23,24, 1957.

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PROGRESS REPORT NO. 2 ON [redacted] JOB 1459 50X1

This report covers work performed under [redacted] Job 1459 during 50X1 the period from September 16 through October 15, 1958.

The work during this period has increasingly been directed toward equipment considerations, in an attempt to arrive at a probable block diagram of the system at an early date. Several important tentative conclusions are being reached and the priority of important problems remaining is being established.

Progress Report No. 1 anticipated the preparation of a special interim report which would discuss in detail the compression ratio requirements and estimate the advantage of various 2WT products. During the present period, however, this work has been assigned a lower priority for two reasons: (1) the ionospheric calculations involved have proven very time-consuming if a realistic statistical sample of cases is to be covered, (2) the ideal requirements on compression ratio are in excess of those previously obtained in practice, and it has become apparent that the principal objective is to build a system with "WT product as large as possible". This work has therefore been subordinated to consideration of equipment for implementing the system.

Dr. Paul Green of Lincoln Laboratories has been contacted and an appointment has been made for consultation on October 20, 1958.

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of Research